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ENKEL 8086

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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF: :

MATS LEIJON ET AL : EXAMINER: ENAD, E.

SERIAL NO.: 09/147,318 :

FILED: FEBRUARY 24, 1999 :

FOR: ROTATING ELECTRICAL MACHINE COMPRISING HIGH-VOLTAGE STATOR WINDING AND SPRING-DEVICE SUPPORTING THE WINDING AND METHOD FOR MANUFACTURING SUCH MACHINE :

DECLARATION UNDER 37 C.F.R. §1.132

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

I, Robert E. Fenton, hereby declare:

1. I am the President of Generation Technology Consultants, Inc., where my mailing address is 2135 Cook Road, Charlton, New York, 12019.

2. My academic background is as follows:

   Bachelor of Science degree in Electrical Engineering from Manhattan College; and

   Master of Science degree in Power Systems Engineering from Rensselaer Polytechnic Institute.

3. My industry experience is as follows:

I have over 30 years of experience in the area of power generation, with the most notable positions as follows:

- **Generation Technology Consultants, Charlton, NY (1997 – Present)**

President/Consultant – Provide expert consultation and technology support relating to generators and power plants worldwide.

- **General Electric Co., Schenectady, NY (1986-1997)**

Power Systems Business – General Manager, Generator Design and Development - Managed and led the design organization responsible for the development of new technology, introduction of new designs, creation of service and upgrade programs for an operating fleet of over 7000 generators rated from 15 MW to 1500 MW. Served as the technology interface with GE generator customers. GE is now, and was then, the leader in both number of generators and technology in the industry.

- **General Electric Co., Schenectady, NY (1980-1986)**

Power Systems Business – Manager, Project Engineering - Managed and led the team responsible for application of generators to new power plants and the technical support for the existing fleet in operation.

- **General Electric Co., Schenectady, NY (1973-1982)**

Power Systems Business – Manager, Application Engineering - Led a team of 12-15 engineers. I was responsible for the decisions on the application of design technology and the introduction of new technology to meet customers' needs and specifications. I also provided frequent customer interface, especially on the most difficult projects.

- **General Electric Co., Schenectady, NY (1967-1973)**

Power Systems Business – Application Engineer – I was a member of the team described above.

4. I have provided a more detailed description of my professional background as Appendix A, attached hereto.

5. In preparing this declaration, I have read and considered at least the following documents pertaining to the above-identified patent application: (1) the patent application (U.S. Serial No. 09/147,318); (2) the Preliminary Amendment filed November 27, 1998; (3) the Office Action dated February 22, 2000; (4) the Amendment filed August 22, 2000; (5) the Office Action dated October 25, 2000; and (6) the Amendment filed herewith. I have also read the following United States patents: (1) <u>Shildneck</u> (U.S. Patent No. 3,014,139); (2) <u>Elton et al.</u> (U.S. Patent No. 4,853,565, hereinafter <u>Elton</u>); and (3) <u>Grant</u> (U.S. Patent No.5,325,008), all of which have been asserted as prior art against the present patent application.

6. Rotating electric machines such as generators play a key role in the electric power production industry in that they are a basic element of a power station system as a whole. From a cost perspective, a generator is a comparatively small component of a power station, but when a generator becomes inoperable, the entire output of the power station is adversely impacted. Accordingly, as a critical system component, the generator plays an important role in the acceptance of new designs of power generation technologies. While improvements in generator design can have great benefits, the risks associated with adopting unproven designs are carefully scrutinized by risk-averse utility owners. The tendency, therefore, is for utility owners to avoid new risky designs and opt for more conventional approaches that have worked reliably and safely in the past.

7. It is important to distinguish what I will call "ordinary" high-voltage machines from the higher-voltage machines of the present invention, which can be directly connected to a power grid. An "ordinary" high-voltage machine is a machine that typically operates below 15kV and in some cases may operate at 30kV or below. ABB's rotating machines based on the ENKEL technology can operate at much higher voltages, for example up to 800kV. This distinction is significant, since ABB's machines do not need a transformer to connect to the power grid, which often operates at 200kV or higher. "Ordinary" high-voltage machines on the other hand, generally require a transformer to step up the voltage between the machine

(in this case a generator) and the power grid. While ABB's machines may be used at "ordinary" high-voltages, they are unique in that they may also be designed to operate at sufficiently high-voltages to connect directly to the power grid.

8. Of course from a system perspective, eliminating the transformer improves system flexibility, increases efficiency by reducing loses, improves reliability by lowering the number of components, and reduces cost.

9. The notion of eliminating the transformer is not new. For example, my former employer, General Electric Company, studied this in the early 1980s, and more recently in April 2000, by GE Canada.[1] In both cases, then and now, GE concluded that there is no reason to believe that rotating machines can be expected to directly connect to the power grid any time soon, due to the complexity of design parameters that are perceived as limiting reliable operation at high-voltage.

10. In the early 1980s, the Electric Power Research Institute (EPRI, an industry funded research organization)[2] commissioned a study to identify a rotating machine with a high-voltage stator winding that could be connected directly to the power grid without a step-up transformer. However, based on the report from General Electric (EPRI's contractor) published in 1982, EPRI concluded that this was not practical. Since that time, the power industry has virtually given up on attempting to build rotating machines that are able to operate at higher voltages. This is due to the perception that the machine would be based on a complex design that would, in all likelihood, suffer from reliability problems. One perceived problem was heat build-up in the rotor, which would result from the necessarily strong electromagnetic field that tended to focus efforts on a monolith cylinder stator and superconducting materials in the rotor that would be able to avoid heat build-up by lowering conductor resistance.

11. GE Canada's more recent (i.e., April 2000) analysis has led them to the same conclusion that "it is not expected to see specification of power system voltages to perhaps 35kV for machines in order to eliminate transformers and breakers." A

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[1] M. Clark, et al., Changing Insulation Systems – Benefits and Problems, Proceedings of 2000 IEEE International Symposium on Electrical Insulation (2000). See Appendix C.

[2] High-Voltage Stator Winding Development, Final Report, Electric Power Research Institute, April 1984. See Appendix B.

related observation was that "[t]he advantages of the higher voltage machines are not going to come without careful analysis of all the factors, some of which many of the current generation of machine designers and insulation specialists are totally unaware." Ironically, ABB has shown that the solution was not to employ a more complex solution, but rather, a simplifying solution.

12. Prior to ABB developing the present inventive technology (sometimes referred to as ENKEL technology), there were only "ordinary" high-voltage generators available on the market, requiring a step-up transformer to connect to the power grid. Until ABB released the ENKEL rotating machines, there were no rotating machines on the market that could be directly connected to a high-voltage power grid supplying power 100s of kV. Furthermore, there remains a general belief among industry members that "it is impractical to try to generate at substantially higher voltages with a conventional generator."[3]

13. Regarding the engineers who work in the appropriate field, in my view a person of ordinary skill in the ordinary high-voltage rotating machines art would typically have an undergraduate degree in Electrical Engineering, Mechanical Engineering or a closely-related specialty, and/or five or so years of professional experience.

14. Ordinary high-voltage rotating machines are a specialized technology, in part because so few companies produce such machines. Furthermore, people with purely academic experience in ordinary high-voltage machinery are frequently not informed about the practical, "real-world" design considerations associated with such ordinary high-voltage machines. Practical experience is a crucial requirement for ordinary high-voltage machine engineers. A fault in an ordinary high-voltage rotating electric machine can lead to a failure of the entire machine due to the large electrical and mechanical forces that are at play. Such a breakdown could not only lead to stopped production at a power station, but also create a hazardous situation for the production personnel working at the power station.

15. Consequently, young engineers work under the close supervision of experienced ordinary high-voltage machine engineers and new designs are carefully

scrutinized to prevent using features that are known to be dangerous or pointless. The risk of including an unproven design feature is simply too great. It is this apprentice-type training approach that is generally followed within our industry.

16. Much of the information gathered by "one of ordinary skill" in the ordinary high-voltage rotating machine art is inherited from more experienced engineers. Thus, significant design changes for ordinary high-voltage rotating machines do not occur frequently, but rather, designs evolve incrementally. The authors from GE Canada of the paper included in Appendix C expressed this concern well when they predicted[4] that moving to higher voltage machines is "not a simple matter" because of the large number of factors affected by high-voltage operation including "clearances, bracing, cooling method, corona suppression, winding terminations and cabling, enclosures, cooling medium, slot grounding, grading, contamination, strand, turn, ground wall insulation, etc." If restricted to conventional design practice, I would agree with the authors from GE Canada. However, what I find most interesting is that the ABB ENKEL technology does address all of these factors with a simple design.

17. The invention described in the subject patent application is directed to high-voltage rotating machines and methods for drawing a high-voltage winding through slots in a stator of high-voltage rotating machines. Such machines may be used as generators in power stations, for example, and could be configured to be directly connected to a power grid without an intermediate step-up transformer.

18. From a number of perspectives, the ABB inventors have done something quite remarkable. First, they were somehow able to convince their company to invest millions of dollars in the idea of developing a high-voltage rotating machine – an idea that that rest of industry, including myself, had given up on. Second, they were able to overcome the challenges of designing and manufacturing a machine that is capable of operating at voltages that exceed 30kV.

19. Traditionally, attempts to design a larger high-voltage rotating machine have focused on increasing the current-carrying capacity in the stator windings, thereby

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[3] Rabinowitz, R., "Power Systems of the Future (Part 4)," IEEE Power Engineering Review, Vol. 20, No. 8, Aug. 2000, p. 4, col. 2. See Appendix E.

[4] It is clear that they were unaware of ABB's recent successes.

making a compact machine with high power output. However, as the current in the windings is increased, the requirements for the insulating materials of the windings are also increased. As higher currents were achieved, higher temperatures were encountered. Extreme temperatures within the confined area of the machine causes the insulation of the windings to break down, which eventually leads to a failure of the whole machine. Accordingly, the development of insulation systems with good heat resistance became a focus for modern research. The proceedings of INSUCON/ISOTEC '98, the table of contents of which are included as Appendix D, and which pre-date the publication of the ENKEL invention are indicative of these efforts.[5] In retrospect, after seeing ABB's high-voltage approach, it seems that the machine designers had focused the insulation industry on the symptom of the high heat resulting from high current operation, while ABB avoided the problem altogether by employing a high-voltage, and thus low-current, design. Since higher voltage does not give rise to heat problems, it is not necessary to use electrical insulation on the cable windings that can withstand ultra-high temperatures. Thus, to some extent, ABB's contrarian design approach showed that the industry's focus on a high-temperature insulation solution did not point to ABB's more simple solution.

20. By focusing on increasing the current capacity of the windings in designing an ordinary high-voltage machine, certain practical limits are encountered, such as failures resulting from high-temperature operation. According to conventional design practice, it was necessary to provide either cooling for the windings, or provide an insulation system that can withstand the heat. Both of these options are unattractive. Cooling the windings with a fluid is unattractive since it adds to the system complexity, and therefore the manufacturing cost of the machine. Also, some coolants are flammable, which can present a fire hazard. Increasing the insulation of the windings is also problematic. As the insulation becomes thicker, it will become difficult to position a large number of winding turns without the machine getting prohibitively large. Furthermore, heat transfer across the insulation from the winding to the outside environment becomes severely restricted.

[5] see, e.g., M. Tari et al., Advanced Technology of Stator Coil Insulation System For Turbo-Generator, Proceedings of INSUCON/ISOTEC '98, at 78 (1998). See Appendix D.

21. Designing an ordinary high-voltage rotating machine to operate at power grid voltages is not a simple matter of scaling-up a lower voltage machine. This point was highlighted in the GE Canada paper:

> Although some work has been done to produce air cooled machines at voltage ratings above 15 kV, it is not a simple matter. . . . Things that were minor problems at lower voltages will become major problems on the new machines. Designers and users will require a new mind set to be able to build and maintain reliable higher voltage machines. The advantages of the higher voltage machines are not going to come without careful analysis of all the factors, some of which many of the current generation of machine designers and insulation specialists are totally unaware.[6]

These are the challenges that ABB faced, but they solved them with a surprisingly simple design.

22. In the 1990s the use of filled materials in insulation systems became of interest as an alternative to asphalt mica and synthetic resin mica. However, it was believed that ". . .this concept has set in motion a new wave in insulation development, with variations over the next decade that may radically change the generator or motor, as we know it today."[7] In light of this prediction of radical changes to generators and motors, it is even more impressive that the engineers at ABB have designed a solution that is not more complex. Thus, while others focused on more complex insulation schemes, ABB used a "systems" approach and, as a result, was able to use a more simple insulation system than others would have expected.

23. The high-voltage electric machine described in this patent application is a "game changer." As reflected in the EPRI study, virtually the entire industry between the mid-1970's and the mid-1990's thought (and some still hold this view) that superconducting generators were the only way to achieve the goal of designing a rotating machine for generating very high-voltages. The general thought was that in order develop an increase in flux, either an increase in the amount of amperage, or the number of turns in the rotor would be required. Because the space in the

[6] M. Clark, et al., Changing Insulation Systems – Benefits and Problems, Proceedings of 2000 IEEE International Symposium on Electrical Insulation (2000).
[7] see M. Clark, et al., Changing Insulation Systems – Benefits and Problems, Proceedings of 2000 IEEE International Symposium on Electrical Insulation (2000).

rotor was limited, efforts were focused on increasing the current through the rotor winding. However, increased current results in increased resistive losses. Accordingly, superconducting materials were viewed as the solution to combat the resistive losses. As far as I know, there is only one superconducting ordinary high-voltage rotating machine in use today, and no superconducting higher voltage rotating machines in use. However, it is used as a testbed environment as part of a $200M program funded by the Japanese government.

24. In arriving at their invention, the revolutionary development by ABB was not in a new material, or a new composition, but rather, taking a different look at the problem. ABB recognized that, contrary to an at least 70 year-old industry tradition, one could design a high-voltage rotating machine by focusing on voltage, rather than current. As a consequence, many of the problems that had been confounding the industry regarding the insulation system could be overcome. With lower currents, which is possible by operating at higher-voltage, the insulation system no longer needed to be designed for such extreme temperatures, nor was liquid cooling always necessary. Furthermore, a flexible cable having an insulation system can be used for a full turn of the winding enabling the use of a semiconductive outer layer which will confine the electric field therein. The winding includes an inner semiconducting layer in electrical contact with a conductor, a solid insulation layer surrounding the inner semiconducting layer, and an outer semiconducting layer surrounding the solid insulation layer. ABB's insulation system was not recognized or considered by the industry since, as discussed above, the industry was pursuing a high-current approach to solving the problem of developing larger ordinary high-voltage rotating electric machines. By focusing on a high-current approach to achieving a high-voltage rotating electric machine, the insulation system of the ABB invention would have never been considered for at least the following reason: the solid nature of the insulation materials would not be able to withstand the extreme temperatures that would be experienced at the current levels being sought, and breakdown would be certain.

25. A long time ago, people had thought of the idea of using flexible conductors in electric machines, however, our experience was that they were seeking a way to lower the cost and improve the reliability of these devices. The Shildneck patent

is an example of such a machine. The idea of using flexible conductors or cables to significantly increase the voltage rating of the generator was not even imagined. This is likely because of the significant and almost overwhelming technical challenges in introducing very high-voltages into electrical machinery. When cost savings did not result from the trial of using flexible conductors, the programs quickly died.

26. It has been conventional practice to use a rigid metallic bar winding that has strong physical properties that can withstand the vibrations and stress of operating in a high-power environment. Using a flexible cable for the windings is completely contrary to conventional practice because the high currents in the windings tends to create large vibrations and stress on the end windings. Based upon my understanding of how the ABB invention works, it is clear that the inventors realized that these problems would simply go away if the current in the windings was decreased by operating at a higher-voltage.

27. Figure 1 illustrates an end-winding portion of a conventional machine that has the conventional rigid bar-type windings. As shown in Figure 1, the rigid bar windings must be pre-formed in separate segments and then separately installed and connected to each other by joints in the end-winding region, Region B. With the use of rigid bar-type windings, it would not be practical to have a continuous winding for all of the turns in the stator. As can be appreciated by one of ordinary skill in the rotating machine art, the manufacturing process of winding a stator is a difficult one involving considerable skilled labor. Shown in Figure 2 is a cross section of a typical bar-type winding, which is made of many segments of rigid metal bars that together form the larger winding.

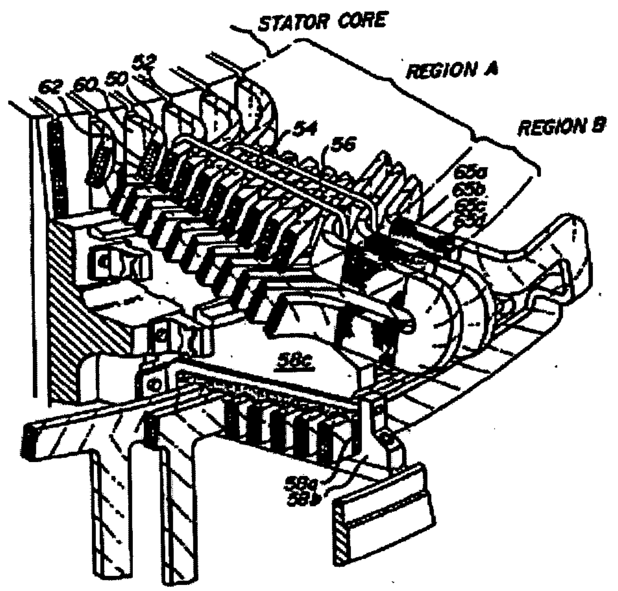

Figure 1 – Machine Having Conventional Bar-Type Machine Windings

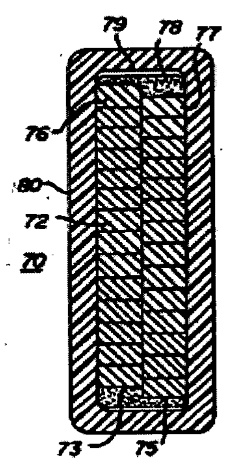

Figure 2 - Cross Section of Conventional Bar-Type Winding

28. Figure 3 illustrates a machine that has ABB's flexible cables for stator windings. As shown in Figure 3, the flexible cable 6 is continuously run through the stator slots 7. Accordingly, there is no need to connect the windings to one another in the end regions. Figure 4 shows a more detailed view of the end-winding region of a machine using ABB's flexible cable windings. By comparing these two figures with Figures 1 and 2 above, it can be easily appreciated that there are many advantages to winding a machine with ABB's flexible cable. The machine includes turns of the winding that are continuous, thereby enabling the avoidance of the problems associated with not containing the electric fields within the windings in the end-winding region experienced using the conventional bar-type windings. While some cable joints may be formed in the end-winding region, certainly every turn in the winding does not include a joint. Also, the ease with which a machine using ABB's flexible cable windings may be wound is a significant advantage from a manufacturing perspective. There will be no need to pre-form the windings. Also, there is no need to form connections and joints for every turn.

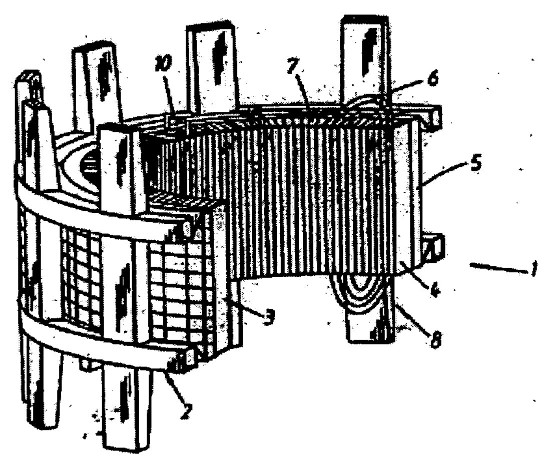

Figure 3 - Machine Having ABB's Flexible Cable Windings

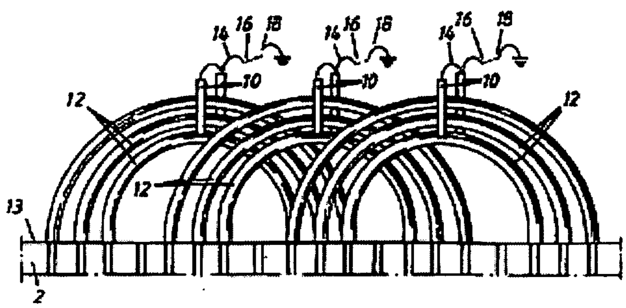

Figure 4 - Detail of End-Winding Region of Machine Having ABB's Flexible Cable Windings

29. As a general matter, rotating machine engineers would not have been motivated to use a flexible cable for the windings in modern machines because the industry had perfected the conventional "bar winding" approach to designing machines, and thus there appeared to be no commercial advantage to substituting a cable winding such as ABB's for the "bar windings" in machines running at ordinary high-voltages. In fact, the experience at GE based on the Schildneck invention (see, U.S. Patent No. 3,014,139) demonstrated that this was not economical. However, ABB determined that by using a flexible cable with the particular insulation system as a winding in a rotating electric machine, not only would the machines be able to operate at power-grid-level voltages eliminating the need for step-up transformers, but the machine design would be very simple, perhaps facilitating the acceptance of the design by the risk-averse utility industry. There would be a huge advantage in having a machine that (a) operates at high-voltage so that step-up transformers are not needed, (b) is able to be manufactured without extravagant cooling techniques, and (c) is based on a relatively simple design so that manufacturing and maintenance problems are reduced.

30. Rotating electric machines using ABB's ENKEL technology are fundamentally different than conventional machines. Figure 5, below is a top view photo showing a stator with cable windings according to the present invention.

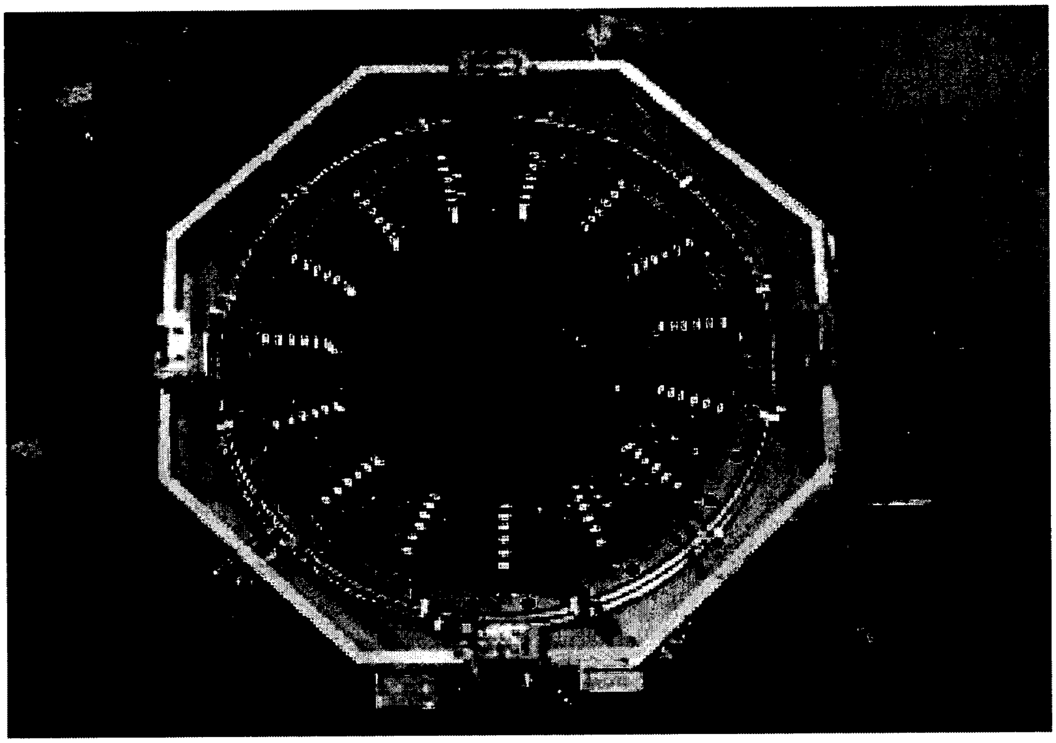

Figure 5: Top View Stator with Cable Windings of the Present Invention

31. The cables in the stator of Figure 5 are continuously looped through the stator slots. In conventional machines, the windings are made of rigid "bar windings" that are fit into the stator slots. Winding a stator with conventional "bar windings" is a labor-intensive job since each of the individual bars must be pre-formed, then "wound" into the stator. Since the winding cable used in the machines of the invention is flexible, the winding process does not include pre-forming the windings, but rather, threading the continuous cable making up the winding turns through the stator slots. One of the reasons that conventional "bar windings" were developed to be mechanically rigid, is to cope with the vibrations due to the electrical forces, which are proportional to the square of the current. Rigid bars provided a natural solution to the attractive and repulsive forces placed on the end-winding portions of the bars due to the currents in the windings interacting with the external electric fields created by the graded voltage from

where the winding emerges from the stator up to the line voltage. The cable used in the windings of the ABB invention can have its outer surface grounded, thereby containing the e-field within the cable. Furthermore, the vibrations are significantly lower due to the high-voltage operation (and thus, lower currents). Consequently, the mechanical integrity of the cable windings in the ABB electric machines is easily assured.

32. Functionally, the more simple[8] generator of Figure 5 can operate at 30kV and above, while conventional generators can not, at least not for any sustainable period of time.[9] As I understand it, the high-power cable used as windings in the generator of Figure 1 is made up of a coaxially-arranged inner conductor surrounded by first, a layer of a semiconducting material, which is itself surrounded by a layer of a solid insulation material, which in turn is surrounded by an outer layer of a grounded semiconducting material. This particular insulation system for the cable winding enables the winding to hold the high-voltage without risk of partial discharge. It is understood that "bar"-type windings are not capable of operating at such high-voltage levels, at least not with modern insulation systems. These further requirements are the main reason that virtually no one is trying to operate at such high-voltage levels.

33. Constructing rotating machines for high-voltage applications gives rise to a number of problems that are not present in conventional rotating machines. For example, to gain a higher voltage, more windings are needed than in conventional machines. Having more winding turns positioned next to each other gives rise to unique cooling problems, and winding vibration problems that can cause the windings to become damaged. Logically, then, one would think that adding more turns to a machine would result in more problems (thermal, discharge, reliability, etc.) being encountered. However, ABB have proved just the opposite: from a system-level perspective, the high-voltage ENKEL machines reduce the number of problems.

[8] I find it interesting that ABB refers to the inventive technology as "ENKEL," which I understand means "simple" in Swedish.
[9] I make this reference to linear motors because one of the asserted references is directed to a linear motor, which operates intermittently and thus has an opportunity to cool itself.

34. Attempts have been made, employing various complex and generally ineffective mechanisms, to develop a high-voltage machine that can operate at power grid voltages without the need for a step-up transformer. However, it is my observation that other companies abandoned their attempts to provide a commercial product. The work of ABB's inventors has now shifted the paradigm since they have demonstrated that high-voltage rotating machines can be implemented using a simpler design, not a more complex one. ABB has inspired others to reevaluate technological solutions for making high-voltage rotating electric machines.

35. I understand that amended Claim 18 is directed to a method for manufacturing a stator with a stator winding for a rotating machine. The method includes drawing a high-voltage cable having an outer semiconducting layer through a first slot, a second slot, and a third slot while a spring member in the slot is compressed, and subsequently uncompressing the spring member once the cable is drawn through the slots. It is significant that the stator winding is made with a cable that is drawn through at least three slots because it means that a least part of the winding turns are continuous through the end winding region. This is an unusual design because in most rotating electric machines greater than 30MW, the windings are manufactured in segments and then connected to one another in an end-winding region (outside of the stator core) by a joint. Thus, it is clear to me that one advantage of having a continuous cable as a full winding turn is that there is no need to make a joint for every turn, thus reducing manufacturing costs. Furthermore, since in conventional designs, vibrations of the end-windings draw a lot of attention by the machine designers, it would not be an obvious choice for a machine designer to substitute a flexible cable for the rigid bar windings used in ordinary high-voltage machines.

In the Spec.?

36. The high-voltage cable used for the stator windings in the present invention includes an insulation system having three layers: first, an inner semiconducting layer; second, a permanent insulation layer surrounding the inner semiconducting layer; and third, an outer semiconducting layer surrounding the permanent insulation layer. The inner semiconducting layer and the outer semiconducting layer each constitute an equipotential surface. One reason for including the outer semiconducting layer is to provide an equipotential surface that can be held at a

predetermined voltage. The equipotential surface confines the electric field to within the cable, and allows the cable to minimize the risk of arcing, or partially discharging, from the cable to other surfaces. The end winding is fully insulated and thus, partial discharges in the end-winding region will be minimized.

37. In the Office Action dated October 25, 2000, it appears the Examiner rejects Claim 18 based on a hypothetical machine constructed by combining a machine having a continuous winding in Shildneck, using an insulated cable from Elton for the winding, where spring members as described in Grant are placed between the stator and the linear motor winding. For the reasons I discuss below, if I did not know about the present invention by ABB, I would not have been able to see why I, or another high-voltage machine engineer, would have been motivated to put these different pieces of prior art together as the Examiner has done. Furthermore, nobody has ever done it, besides the Examiner.

38. The Examiner uses the cable from Elton as a winding in the stator from Shildneck for the reason that the cable from Elton "would provide a cable that is flexible, prohibit the development of corona discharge and equalize the electrical charge generated between two layers." The Examiner goes further, in using the spring from Grant to secure the cable in the stator slot. In my view, this assertion is unreasonable, and must have been made without the benefit of understanding the technical and functional objectives of the present invention, Shildneck, or Elton.

39. The Examiner asserts that the machine in Shildneck teaches the machine claimed in the present application with the exception of the winding having at least one semiconducting layer around the conductor and using spring members in the stator slot to reduce vibrations.[10] In rejecting the claims, the Examiner asserts that it would have been obvious to one of ordinary skill in the art at the time of the invention to have provided in the machine of Shildneck, an electric cable as a winding having "an electrical conductor comprised of a solid insulation layer 106 between two semi-conducting pyrolyzed glass fibers 104, 110, the internal grading layer 104 surrounding the conductors of cable 100,"[11] as disclosed by Elton. The Examiner asserts that making such a combination would "provide a cable that is

[10] See Office Action dated October 25, 2000, page 2, numbered paragraph 2.
[11] See Office Action dated October 25, 2000, page 3, first full paragraph.

flexible, prohibit the development of corona discharge and equalize the electrical charge generated between two layers."[12]

? where ?

40. Shildneck describes a conventional low-voltage, high-current machine. As such, the design of the machine in Shildneck does not consider the problems that exist in high-voltage machines such as partial discharge and high temperatures. During my employment with General Electric (the assignee of the Shildneck patent), it was my pleasure to work with at least one engineer who, as a young man, was part of the engineering team that designed the cable-wound generator of Shildneck. The avowed goal of attempting to use a cable-like winding in the Shildneck machine was to determine if the technology might offer significant cost savings compared to the use of coils or bar-type windings at conventional voltages. Through my employment at General Electric, I became familiar with the work surrounding the machine described in Shildneck, and happen to know that this attempt failed to achieve its objectives because the system, although operable at low voltages, was not cost effective. In a discussion with the Shildneck team member mentioned above, in light of the ABB publications of the ENKEL technology, I asked him if anyone had conceived of the concept of designing this generator for higher voltages. He emphatically advised me that cost reduction at standard voltages was the only objective. I should add that Mr. Shildneck was considered one of the more creative engineers of his time at General Electric and this engineer from his team later became a leader in the design of air cooled generators. Both were significantly more advanced than "one of ordinary skill in the rotating electric machine art!"

Nis in there? Shildneck recognized the problem!

41. The Shildneck reference does not in any way suggest the desirability of increasing the voltage. The operation of Shildneck is inherently limited to conventional voltages due to (1) the use of an insulator as the outermost layer of the winding; and (2) the lack of any type of description of how to eliminate corona between an insulated conductor and a metallic member. Corona will form in any small air pocket between the insulation material and the stator slot, provided that sufficient voltage develops across the air space. When the corona builds up at these positions the insulation material will eventually deteriorate, ultimately leading to a

[12] See Office Action dated October 25, 2000, page 3, last paragraph – page 4, first paragraph.

breakdown of the machine. Machines that operate at higher voltages are usually provided with some kind of E-field control in the end-winding region. Corona protection varnish is often used. This E-field control evens out the dielectric stress of the insulation material in the end winding region, but electric field concentrations are still a severe problem in electrical machines operating at these higher voltages. Shildneck does not use an E-field control, and actually uses silicon rubber as the ground insulation, which would surely deteriorate when exposed to inevitable corona if the machine were to be operated at higher voltages. Accordingly, Shildneck is configured for use only at low-voltages.

42. I do not agree that combining the low-voltage machine of Shildneck with the cable of Elton would result in a high-voltage machine that would be operable in a commercial-usage context.

43. As the teaching of the Shildneck patent was to develop a low-voltage machine having a cable winding, the materials selected and presented in the teaching are those suitable for those ordinary high voltages. An objective of Shildneck was to achieve generator voltages from 10 kV to 15 kV (13.8kV being the most frequently used voltage for these generators). The materials used in the cable in Shildneck, although acceptable for use at these voltages, are totally unacceptable at higher voltages such as those voltages at which the ENKEL technology operates.

44. There is nothing in Shildneck that suggests to me that higher voltages are desirable, nor is there any suggestion in Shildneck that the insulation system of the winding proposed therein could be modified in order to achieve higher voltages.

45. There is nothing in Elton to suggest that the cable shown in Figure 7 thereof could be used as a stator winding in a high-voltage rotating machine. Rather, Elton is directed to a pyrolyzed glass fiber layer that can be used in several applications. One such application discussed in Elton is for providing a semi-conducting layer around conventional bar-type windings of an electrical machine to bleed off charges thereon and to minimize the possibilities of a corona discharge.[13] Another application discussed in Elton is for using the semi-conducting pyrolyzed glass

[13] See Elton, column 2, lines 44-48.

fiber layer in a cable to equalize the electric charge on the exterior of the insulator of the cable.[14] These are but two examples disclosed in Elton for applying the inventive pyrolyzed glass fiber layer. It should be noted, however, that nowhere in Elton is it suggested that one could use the cable as a winding in an electric machine to replace the conventional bar-type windings to achieve higher voltages. The use of the pyrolyzed glass fiber layer in the bar-type windings and in the cable are two disparate uses of the pyrolyzed glass fiber, no more connected in the Elton reference than are the bar-type winding and the use of the pyrolyzed glass fiber for surrounding a housing for electric equipment, shown in Figure 8 of Elton. It is the various uses of the pyrolyzed glass fiber that Elton teaches, not the use of an exemplary cable as a winding in a rotating electric machine, as is suggested by the Examiner.

Dv.?

why use it?

46. Consequently, I cannot agree with the Examiner that it would have been obvious to one of ordinary skill in the rotating electric machine art, to combine the low voltage machine having cable windings of Shildneck with a cable used to demonstrate an exemplary use of a pyrolyzed glass fiber layer in Elton to arrive at the high-voltage machine of the present invention. Such a combination, as discussed above, would not produce an operable high-voltage machine, and certainly would not produce a machine capable of operating at the voltage levels achievable by the present invention.

47. Grant is asserted for its description of using spring members to hold a winding in stator slots. I am quite familiar with this patent as it was developed under a program that I funded while at GE using the skills of Mr. Grant who was my employee. This patent was successfully applied to a large number of generators while I was at GE and since I left. As can be seen in Figure 1 of Grant, the winding 14 is a "stator bar" (col. 4, line 57) and not a cable, and thus the springs are flat and were specifically intended for generators at 30 kV or less., not in an arc shape, as would be used to support a round cable. Aside from the springs, there is nothing in Grant that would facilitate the combination of the low voltage machine having a cable winding of Shildneck with the cable disclosed in Elton to arrive at the high-voltage machine of the present invention.

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[14] See Elton, column7, lines 12-21.

48. I further state that all statements made herein to my own knowledge are true and that all statements made herein on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such any willful false statements may jeopardize the validity of the application or any registration resulting therefrom.

Robert E Fenton — 4-20-01

Robert E. Fenton — Dated